II

DEPARTMENT OF THE INTERIOR—U. S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

THE

ATLANTIC COAST TRIASSIC COAL FIELD

BY

JAY BACKUS WOODWORTH

EXTRACT FROM THE TWENTY-SECOND ANNUAL REPORT OF THE SURVEY, 1900-1901
PART III—COAL, OIL, CEMENT

WASHINGTON
GOVERNMENT PRINTING OFFICE
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THE ATLANTIC COAST TRIASSIC COAL FIELD.

By JAY BACKUS WOODWORTH.

INTRODUCTION.

The Triassic coal areas of the Atlantic coast are included in the southernmost of a number of isolated trough-shaped basins of conglomerate, sandstone, and shale, with intrusions and occasional buried flows of basic igneous rocks. The name Newark was given by Redfield to the beds of which these basins are composed, on account of their occurrence at Newark, N. J. The northernmost of the Newark areas borders the Bay of Fundy and the southernmost occurs in South Carolina. The area in Massachusutts and Connecticut and the elongate tract extending from Orange County, N. Y., through New Jersey, Pennsylvania, and Maryland, into northern Virginia, are not known to contain coal except in isolated films associated with the fossil remains of single plant stems, as in the sandstones near Belleville, N. J., and in the inch-thick layers at Phœnixville, Pa. This report, therefore, discusses only the southern coal-bearing areas lying within the States of Virginia and North Carolina.

GEOGRAPHIC RELATIONS.

These southern coal areas lie in the Piedmont district, midway between the Blue Ridge Mountains and the Atlantic Ocean. This is a region of little relief, easily traversed in any direction by roads and railways, and having on its eastern border ready access to tide water by means of the James and Cape Fear rivers.

The productive tracts occur in two well-marked belts in Virginia and North Carolina, with an intermediate tract in Virginia. These belts extend for about 250 miles in a southwesterly direction, over an area nearly 100 miles wide.

The eastern belt includes the Taylorsville and Richmond areas in Virginia, and the Deep River area in North Carolina. The western belt includes the Dan River area. Between them lies the Farmville area in Virginia. The areas in Virginia will first be described, then those in North Carolina.

TAYLORSVILLE AREA, VIRGINIA.

The Taylorsville area is unimportant and unpromising. It lies on the extreme eastern edge of the Piedmont district about 20 miles north of Richmond, Va. The beds are exposed in the vicinity of Taylorsville, a station on the Richmond, Fredericksburg and Potomac Railroad. Little is known of the stratigraphy of the area.

The width of the area is about 8 miles, its length approximately 10 miles in a northwest-southeast direction. It is estimated to have an extent of 60 square miles.

Coal, it is reported, has been found, but a shaft sunk upon the bed did not give sufficient promise to lead to its development.

RICHMOND AREA.[a]

The Richmond area is the most important of the Triassic coal fields. It has been the longest known and the most extensively worked.

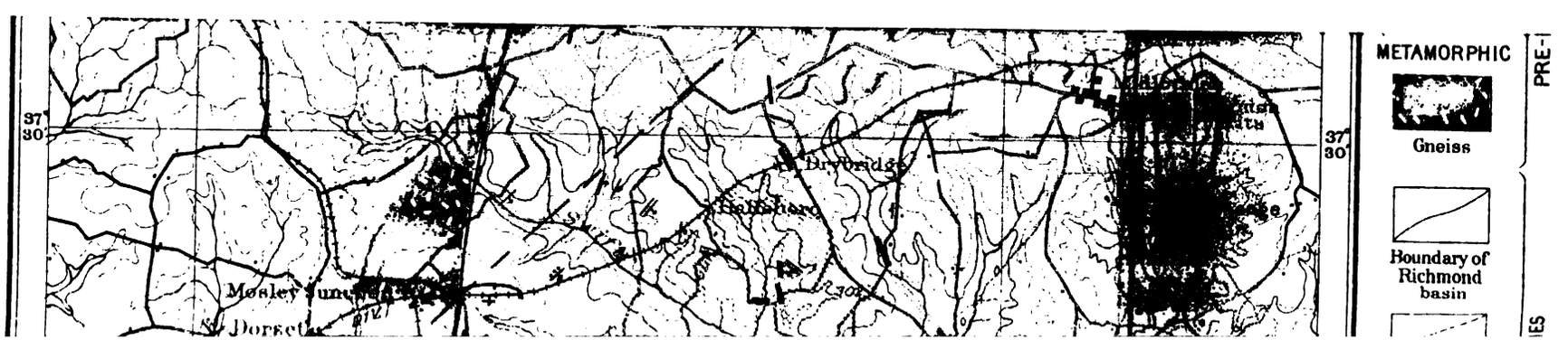
LOCATION AND BOUNDARIES.

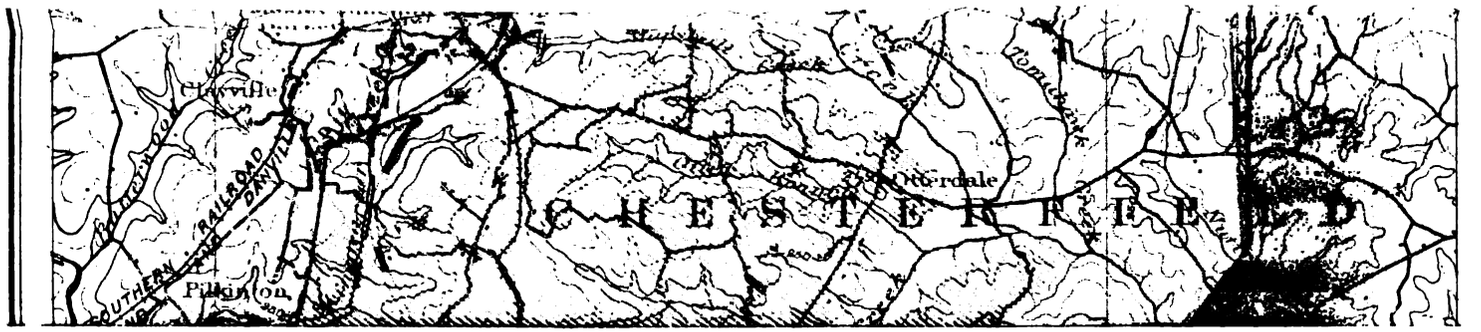
The area is situated on the eastern margin of the Piedmont district, and its eastern outcrop is but 13 miles from the head of tide in the James River at Richmond. It lies in Goochland, Henrico, Powhatan, and Chesterfield counties, and extends about 31 miles north and south, beginning 9½ miles north of the James River and extending to a d beyond the Appomattox on the south. Its greatest width is nearly 10 miles in the southern middle portion, from which it tapers toward either end. It has an area of approximately 150 square miles, the greater part of which is believed to be coal bearing, though the central portions are unexplored.

The eastern border, as shown on the map (Pl. II), is tolerably regular, with few offsets, and is readily traceable in the field. The western border is less regular and not so clearly shown.

The area has the form of a broad basin, along the eastern edge of which the coal horizon has been traced except where covered by alluvium in the Swift Creek drainage area. On the east of the main area north and south of the James River occur a few small outlying basins, now worked out. The Flat Branch or Springfield pits area lies east of Gayton; the Blackheath and Cunliff basins, and the Union pits and Stonehenge areas, lie east of Midlothian. The western margin of the field shows coal outcrops in the immediate vicinity of the James River. The largest developments have been on the eastern margin, at Gayton and Deep Run, north of the James, at Midlothian and the attendant basins south of that river, and in the southern portion of the basin at Winterpock (Clover Hill of the old reports). On the western margin the Manakin mines and the Old Dominion and Norwood workings have been the most prominent.

[a] Chesterfield coal field, Richmond deposit, Richmond coal field, of various authors.


37°30'
37°30'
Drybridge
Hallsboro
Mosley Junction
St. Dorsett
METAMORPHIC
Gneiss
Boundary of Richmond basin
PRE-I
ES


Clayville
Pittsylvania
Otterdale
CHESTERFIELD
Doubtful boundary of main basin
Approximate boundaries between formations
BOUNDARI

GEOLOGIC RELATIONS.

AGE OF THE COAL-BEARING SERIES.

The coal-bearing rocks occur near the base of the Newark formation, and from their included plants have been in recent years held to be of Triassic age, in agreement with similar evidence from the other Newark areas.

The area is bordered on the east by coarse granites, which form the floor of the Triassic sediments on that side of the basin. About the northern and southern ends and along the western side of the area gneisses replace the granite and undoubtedly underlie the western half of the area. These rocks are presumably of Archean age and are readily distinguished from the coal-bearing strata.

STRATIGRAPHY.

The strata in the Richmond area have been recently grouped by Shaler and Woodworth in the following order, beginning at top:

Strata in the Richmond area.

	Feet.
Otterdale sandstones: Coarse sandstones, often feldspathic, with silicified trunks of Araucarioxylon and local lignite beds; developed about Otterdale in the southern and western parts of the area	500±
Vinita beds: Mainly black fissile shales with *Estheria ovata*, intercalated with grayish sandstones; exposed in the James River bluff and on Tomahawk Creek	2,000±
Productive coal measures: Interstratified beds of bituminous coal, usually three beds, with black *Estheria* shales, plant-bearing shales, sandstones.	500±
Lower barren beds: Sandstones and shales, often largely arkose or granitic sandstones on eastern margin	0 to 300
Boscabel bowlder beds: Local deposits mainly seen on the western margin.	0 to 50

These sediments are not well exposed, and the accompanying map (Pl. II) shows approximate boundaries only.

STRUCTURE.

The basin in the region of the James River has the general appearance of a broad, shallow syncline, with the beds dipping westward along the eastern margin, essentially flat with flexures downthrown to the west in the central part, and much broken but dipping mainly eastward on the western margin, where the coal-bearing rocks again rise to the surface. North and south of this river section the strata show evidence of faulting along the western margin by which the coal beds are thrown down at varying distances to different depths. Hence there is a general failure of the coal outcrop along the western margin. On the eastern margin, particularly toward the south, the westward-dipping strata have been deformed and have been forced into the form of north-south troughs. These are separated by arches, over the crests of which the coal beds are more or less completely pinched out.

Experience at the Winterpock mines has shown that by driving the slope downward and through one of these arches or "rolls," the coal is encountered on the opposite or lower side in approximately the same plane of descent.

A few borings made along the eastern margin confirm the evidence derived from mining that the dip carries the coal-bearing strata to a depth of 2,500 feet in the tract south of the James River at a distance of a mile from the eastern margin. Greater depths for the coal are indicated in the southwestern part of the field by the prevalent westerly dip in that district.

Detailed study of the structure of the basin has shown that the disturbances in the strata originated in the underlying granites and gneisses and that the strata are most broken and flexed in the lower beds, as shown in the old workings about the margins. It is to be expected, if this view be true, that disturbances will be encountered in the deeper beds of the central part of the area, notwithstanding the general flat position of the strata at the surface. There are indications

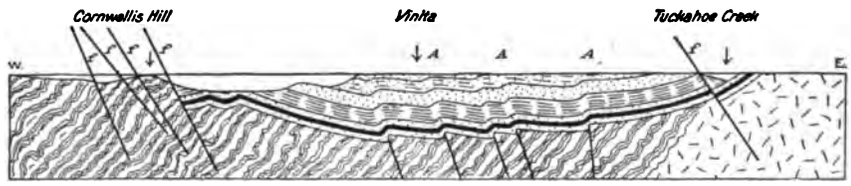
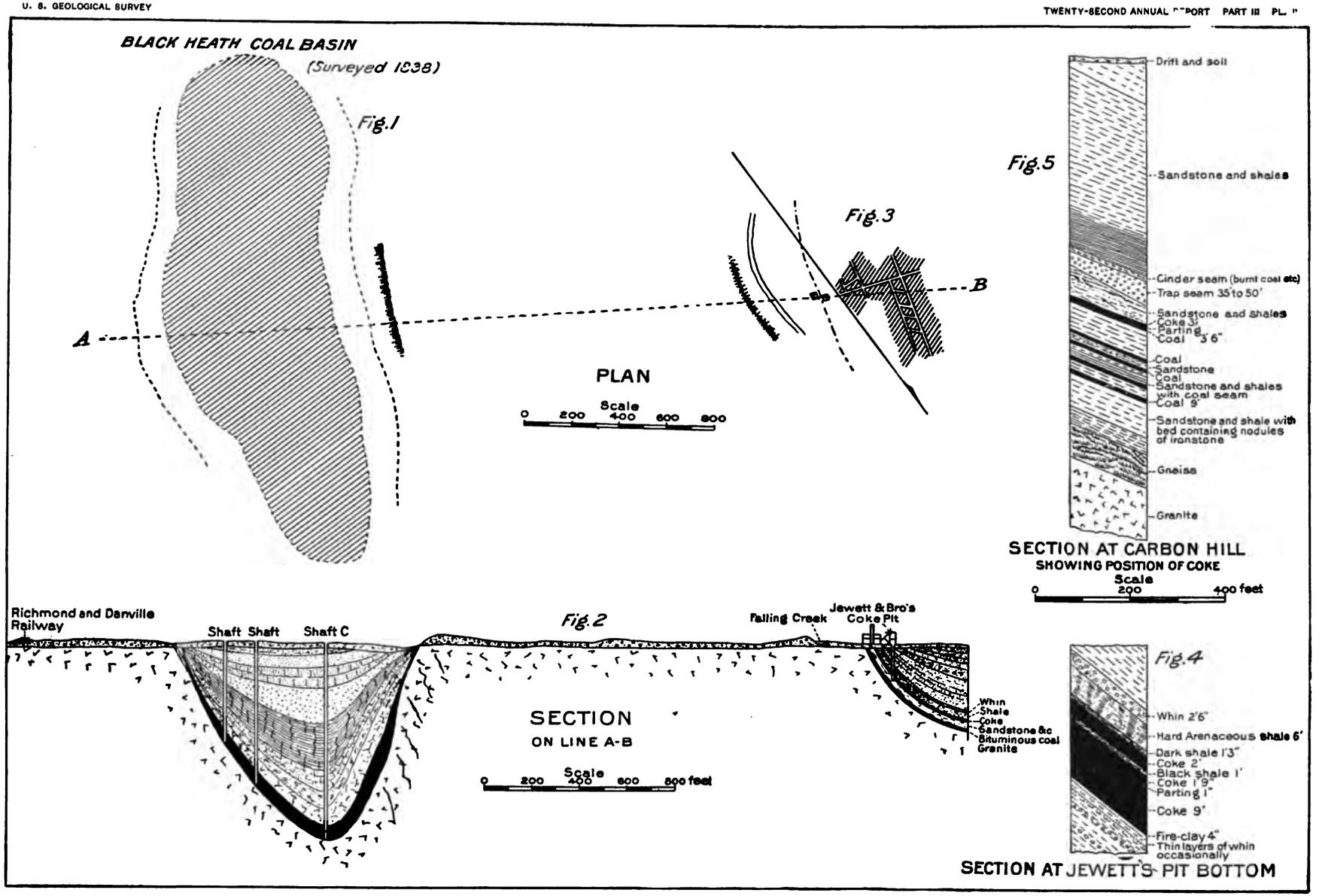


FIG. 1.—General structure section of the Richmond Basin in the vicinity of James River. *A*, *A*, *A*, minor flexures, with beds downthrown to the west; *f*, *f*, *f*, faults. The heavy black band represents the supposed position of the coal beds. North and south of this section the beds appear to be deeply faulted down against the western margin, and the apparent synclinal structure disappears. The superficial portion of this section is based on observation and reliable information; the deeper portion is hypothetical.

of faults in this central area as well as flexures or sudden changes of dip. Even where the beds are flat at the surface a drill hole may intersect inclined strata at a depth, showing that the flatness of the surface outcrops can not be relied upon as indicating the lack of disturbance in the beds beneath. The flexures with westward dips seen in the James River bluffs also make it probable that coal beds in that section will be found with occasional sudden downthrows along faults or flexures as the coal is followed toward the western margin, where the strata rise again toward the surface.

There are no well-marked horizons of peculiar rocks overlying the coal which will serve as a guide to the drillman in indicating how far he may be at any given time above the coal beds. Boring should be continued until coal or the light-colored granitic or gneissic basement is encountered. Care should be taken to avoid sinking a drill hole upon one of the numerous trap dikes which intersect the field. Preferably a drill hole should be sunk to the west of a known dike, fault, or flexure shown at the surface, for the reason that the dip of these



PLAN AND SECTIONS OF OLD WORKINGS ON EASTERN BORDER OF RICHMOND BASIN.

(After Clifford.)

secondary structures, so far as known in the central portion of the field, is steeply eastward. To drill near the eastern margin of these disturbances may be to encounter them lower down. The trap is normally a hard, dense, black crystalline rock, but where it is in contact with or has intersected a coal bed and converted the latter partly or wholly into natural coke, the trap is also altered into a soft white rock resembling clay. Intrusive sheets of this rock are to be expected in the coal measures in any part of the field.

THE COAL.

NUMBER, THICKNESS, AND EXTENT OF THE BEDS.

On the eastern margin of the main basin there are usually three workable beds. At Gayton, on the north side of the James, Coryell

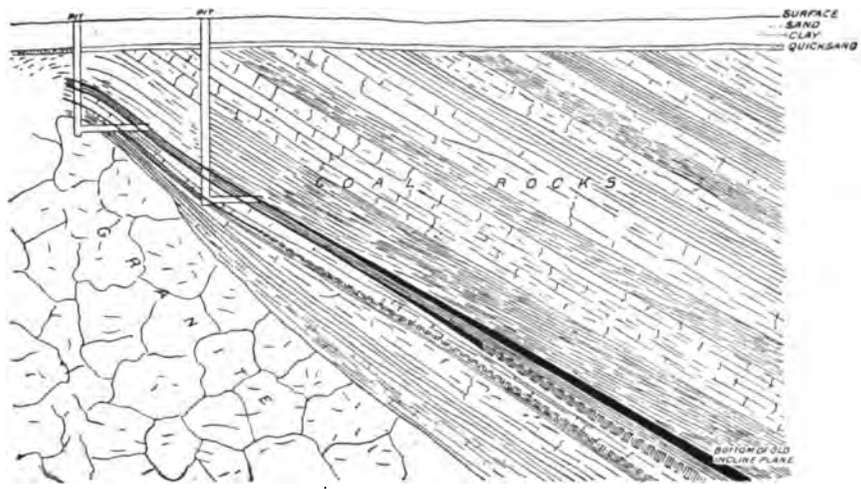


FIG. 2.—Section at the Powhatan Coal Company's colliery. (After Bladon.) Scale: 1 inch = 130 feet.

found four; the uppermost was unexplored, that next below was 6 feet in thickness, the next 5 feet, and the lowest, mainly natural coke, 6 feet. According to Daddow and Bannon, there is in this field, 50 feet above the granite, a bed of lean iron ore (15 to 20 per cent) 2 to 8 feet thick. Above this is a bituminous coal bed from 5 to 10 feet thick, but banded with slate; over this is a 4-foot bed, which is succeeded by a good workable coal from 5 to 7 feet thick. The upper or natural coke bed ranges from 5 to 6 feet.

In the abandoned Sallé and Burfoot tracts on the south bank of the James, near the site of Bellona arsenal, Lyell found the upper bed to be 30 feet, the middle 3 feet, and the lower 1 foot thick.

In the old workings at Midlothian one bed is described as having an average thickness of 20 feet, being 36 and as much as 50 feet thick

in places. Heinrich reports three beds encountered in a boring near Grove shaft south of Midlothian of which the upper had a thickness of 14.5, the middle 12 feet, and the lower 3.5 to 4 feet. At Winterpock (Clover Hill), three beds were encountered, the middle one being the thickest. The developments have not been sufficiently extended to show as yet whether the beds are continuous from mine to mine along the eastern margin. It is the opinion of miners that they are not. But both the present and abandoned mines are reported to show a good breast of coal at the lower end of the slopes which have been driven down the dip.

On the western margin, at Manakin, three beds were encountered, the upper from 6 to 8 feet in thickness, the middle 12 feet, and the lower 3 to 4. In the Powhatan Coal Company's workings on the south side of the James there is an upper bed increasing from 2 feet near the surface to 10 feet at a depth of 400 feet, with two beds of less well-known thickness below. (See John Bladon's section, fig. 2, p. 35.)

The thickness of the coal beds and their known extent under the basin in the region bordering the James River furnish presumptive evidence that the beds are continuous beneath this portion of the area. Judging from structures observed at the surface, the coal beds probably occur at a somewhat less depth than in the southern parts of the basin.

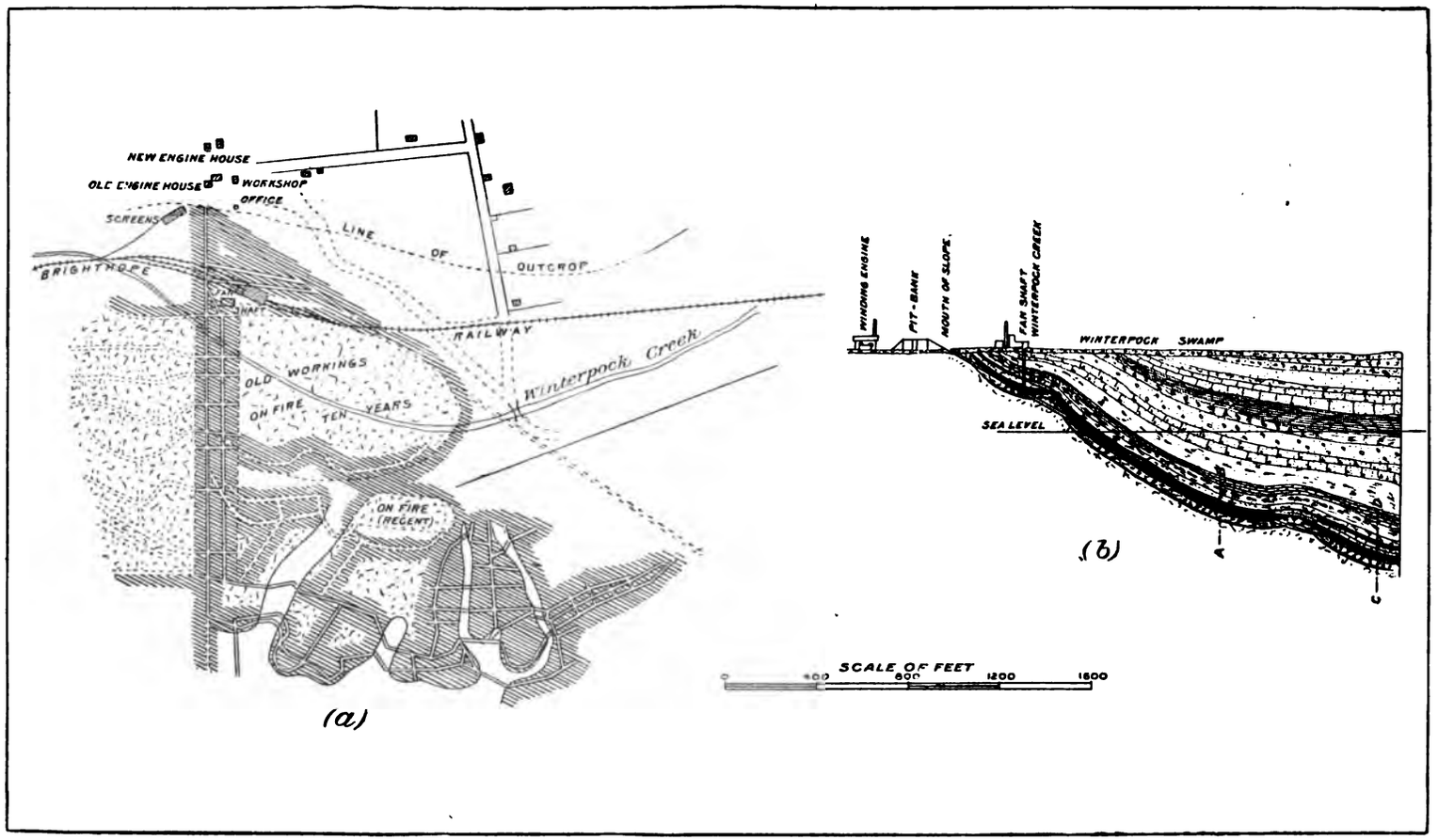
The accompanying figures (Pls. III and IV), reproduced from Clifford's report, show the available knowledge concerning the extent of the coal at Jewett's coke shaft (long abandoned), at Midlothian, in the Blackheath area (worked out), and at Winterpock.

CHARACTER OF THE COALS.

The coal of the Richmond Basin is normally bituminous and coking. Some years ago a few coke ovens were erected at Gayton and a limited amount of good coke was produced, which found a ready market in Richmond. In the portion of the basin northward from the vicinity of Midlothian at least one of the beds is usually converted, either wholly or partly, into natural coke or carbonite.

NATURAL COKE, OR CARBONITE.

The natural coke occurs associated with intrusions of diabase, either in the form of dikes which cut upward across the beds or as sills which follow the coal bed on the rise. These sills and certain of the dikes have been altered into soft gray rock, and in immediate contact with them the coke assumes a prismatic habit. This coke is cellular, burns slowly unless under a strong draft, snaps when burning, and is known as hard or "popping coke." The best variety, found more remote from the igneous rocks and known as soft or free-burning coke, occurs in rather dense blue-black masses suitable for household purposes.



PLAN AND SECTION OF RACCOON MINE, NEAR WINTERPOCK.

(After Clifford.)

The following analyses of natural coke from the Richmond Basin show its composition:

Analyses of coke from Richmond Basin.

Constituent.	I.[a]	II.[b]
Carbon	80.30	67.13
Volatile matter	9.98	18.35
Ash	9.72	12.86
Water	.....	1.66
Sulphur	.....	4.70

[a] Coke from a heavy bed on the eastern margin near the James River; W. B. Rogers, Geology of the Virginias, reprint, 1884, p. 535.

[b] Natural coke collected by I. C. Russell from Midlothian: Bull. U. S. Geol. Survey No. 42, 1887, p. 146. Analyst, R. B. Riggs.

At Gayton (Carbon Hill) the lower bed is coke. When examined by the writer in 1897, in the Saunders slope at a depth of 650 feet from the surface, the coke bed was about 9 feet thick, the lower 2 feet being relatively unaltered coal.

ANALYSES OF THE COALS.

W. R. Johnson presented in 1844 an exhaustive report on the steaming and other properties of the Richmond coals, for the numerous details of which his report should be consulted. The following data are taken from his work.

Synoptical view of the characters and composition of certain coals from the Richmond area, according to W. R. Johnson (1844).[a]

Designation of coal.	Density.				Composition in 100 parts.						Fuel ratio.
	Specific gravity.	Pounds per cubic foot, calculated from specific gravity.	Weight in pounds per cubic foot by experiment.	Cubic feet of space required to stow 1 ton.	Moisture, determined by steam drying.	Volatile matter, other than moisture.	Fixed carbon.	Sulphur.	Coke.	Earthy matter.	
Barr's Deep Run	1.382	86.410	53.174	42.126	1.785	19.782	67.958	.....	78.433	10.475	3.43
Crouch and Snead's	1.451	90.710	53.593	41.797	1.785	23.959	59.976	0.427	74.256	14.280	2.50
Midlothian (900-foot shaft), average	1.437	87.497	50.518	44.340	1.172	27.278	61.083	.....	71.550	10.467	2.62
Midlothian, average	1.294	80.895	54.044	41.450	2.455	29.796	53.012	0.058	67.749	14.737	2.20
Midlothian, screened	1.283	80.210	45.722	48.990	1.785	34.497	54.063	0.202	63.718	9.655	1.84
Clover Hill	1.285	80.355	45.485	49.250	1.339	31.698	56.831	0.514	66.963	10.182	2.11
Chesterfield Mining Co.	1.289	80.565	45.549	49.180	1.896	30.676	58.794	1.957	67.428	8.634	2.20

[a] Report of experiments on the evaporative power and other properties of coals, made under authority of the Navy Department of the United States. 28th Cong., 1st sess., Senate No. 386, pp. 1-607; see pp. 308-451. 1844.

Analyses of coals given by Prof. W. B. Rogers, 1840.[a]

Designation of coals in 1840.	Fixed carbon.	Volatile matter.	Ash.	Color of ash.
FROM NORTH SIDE OF JAMES RIVER.				
Capt. Thomas M. Randolph's	66.15	30.50	3.35	Light red.
Coalbrookdale, second seam	66.48	29.00	4.52	Light gray.
Anderson's pits, first seam	66.78	28.30	4.92	Do.
Barr's pits:				
First seam	70.80	24.00	5.20	Faint red.
Second seam	54.97	22.83	22.20	Strong red.
Third seam	65.50	24.70	9.80	Light brown.
Fourth seam	56.07	21.33	22.60	Strong red.
Crouch's lower shaft, upper seam, 110 feet below surface.	64.60	30.00	5.40	
Scott's pits, formerly Woodward's	60.86	33.70	5.44	Light gray.
Waterloo shaft	55.20	26.80	18.00	
Deep Run pits	69.84	25.16	5.00	
FROM SOUTH SIDE OF JAMES RIVER.				
Stonehenge	58.70	36.50	4.90	Light reddish.
Engine shaft:				
Maidenhead	63.97	32.83	3.20	Strong red.
Heth, Potts & Co.	62.35	37.65	2.80	Reddish yellow.
Mills and Reids Creek pit	57.80	38.60	3.60	Buff.
Will's pit	62.90	32.50	4.60	Light brown.
Greenhole shaft	67.83	30.17	2.00	Light red.
Colonel Heth's deep shaft (seam 30 to 40 feet thick):				
Bottom of seam	53.36	35.82	10.82	Light pinkish brown.
Middle of seam	66.50	28.40	5.10	Light brownish yellow.
Top of seam	61.68	28.80	9.52	Light pink to brown.
Powhatan pits, formerly worked by Captain Finney.	59.87	32.33	7.80	Pale buff.

DEVELOPMENT.

HISTORY.

The occurrence of coal in this area was known as early as 1700, and the coal was used as early as 1775. In 1789 shipments were made to Northern cities. A bed 24 feet thick was mentioned by Volney in 1803. According to Mease,[b] the general use of the coals in Richmond as early as 1807 was credited with lessening the febrile ailments of the inhabit-

[a] Geology of the Virginias, reprint, 1884, pp. 533–535.

[b] A Geological Account of the United States, by J. Mease, Philadelphia, 1807, p. 413.

ants. This medical opinion of the time is mentioned here as showing the general use of the coal at this period. The unusually thick beds of coal in the small detached basins on the eastern margin were early and quickly won, and during the thirties and forties the mining operations here were the most extensive in the United States. English capital later became interested in the Midlothian field, and a durable pumping shaft house and other structures were erected, only to be abandoned because the coal bed appeared to be local and worked out.

Three fields on the eastern outcrop of the main basin have been long worked in a small and intermittent way north of the James at Gayton (or Carbon Hill), the vicinity of Midlothian, and at Winterpock (Clover Hill of the old reports). A small amount of coal is still being mined at Gayton and Winterpock. The Midlothian field was abandoned a few years ago because of the burning of the surface equipment, but not, it is stated, for lack of coal in sight in the workings. On the western margin the Norwood, Old Dominion, and Scott's pits, on the south side of the James, and the Manakin mine, on the north bank of the river, were worked to a small extent, but have for many years been abandoned.

An attempt to reach the coals near Midlothian was made in 1874 by the "sinking shaft," which was abandoned before the horizon at which the coal occurs was reached. At present the deeper lying coals are reached at Gayton and Winterpock by slopes driven down from the eastern outcrop or driven from the foot of shafts sunk near that outcrop.

METHODS OF MINING.

The larger mines in the best days of this field were worked on the English plan by means of shafts and slopes. An inspection of Clifford's plans of the Raccoon coal mine near Winterpock (Pl. IV), of Jewett's coke shaft, and the old Black Heath workings (Pl. III), will give an idea of the method of entering the ground. Water has been raised largely by means of buckets, and in many ways the methods employed have been rather those of the early part of the century than those now most approved. The shafts are sunk to depths determined by the distance from the outcrop. North of the James there were at one time as many as twelve of these shafts within a mile. Graham's or Anderson's shaft was 450 feet deep. On the south side of the James the shafts were from 400 to 500 feet deep. The Midlothian Company's shaft reached the coal at a depth of 722.5 feet and went through 36 feet of coal, with a sump 16.5 feet deep. The Gowrie shaft was 460 feet deep.

The gaseous nature of the coals has led to a few serious explosions, fires, and much loss of life. The first explosion took place in 1817. In 1839 an explosion took place in one of Heath's pits by which 53 out of 56 persons in the mine were lost. Other explosions had previously

occurred in the Maidenhead pits. Explosions took place in 1841 in Will's pits, in 1844 in the Blackheath basin, and in 1854 19 men were killed in the Chesterfield coal pits, then over 600 feet deep. In 1854 or 1855 an explosion took place in the Midlothian Coal Company's shaft by which 55 men were killed In 1835 the Blackheath mines were on fire, and the Bell workings had been on fire for twenty-five years. The history of these accidents shows the need of the most improved means of ventilation in this field.

LABOR EMPLOYED.

In the earlier days colored labor was largely employed under the supervision of English and Welsh miners. At present Hungarian and colored labor, under the direction of local and Pennsylvania mining engineers, is employed. No accurate statistics exist as to the number of men or the wages paid.

STATISTICS OF MINES AND PRODUCTION.

Accurate statistics of the mines and of the production of this field, particularly in its former best days, are wanting. R. C. Taylor estimated the production for twenty years as follows:

Estimated coal production of Richmond Basin from 1822 to 1842.

	Tons.		Tons.
1822	48,214	1836	110,714
1824	59,857	1838	96,428
1826	79,214	1839	85,714
1828	89,357	1840	78,571
1830	91,786	1841	71,071
1832	117,857	1842	65,750
1834	110,714		

According to the census of 1870, 61,803 tons were mined in the State of Virginia, most of which probably came from this field. According to the Tenth Census report, 40,520 tons were mined in the Richmond area in 1880. The following statistics have since appeared; those from 1895 to 1900 are from transportation companies:

Statistics of coal production in Richmond Basin from 1885 to 1892 and 1895 to 1899.

	Tons.		Tons.
1885	50,000	1896 [a]	1
1886	28,000	1897 [a]	130
1887	50,000	1898 [a]	53
1892	33,600	1899 [a]	21
1895 [a]	1,076		

The mines in this field have frequently changed hands. The references cited by Russell give a clue to the names of many firms engaged in this field in the past.

[a] From Midlothian only. Since 1896, largely shipments by individual miners from old workings.

According to the Mining Directory of the Tenth Census* the following mines were working in Chesterfield County, Va., in 1880:

1. Bright Hope, at Clover Hill, operated by Bright Hope Railroad Company; top, middle, and bottom seams, 27 to 30 feet thick; product in tons of 2,000 pounds, 19,040. Markets, Richmond, Petersburg, Norfolk, Va., and tide-water cities on Atlantic coast.

2. Cunliff mine, at Coalfield, operated by George H. and John Jewett; product, 6,720 tons; thickness of seams, 25 feet. Market, Richmond, Va.

3. Union mine, at Midlothian. Operator, Jacob Baach; product, 1,638 tons; thickness of coal, 8 feet. Market, Richmond, Va.

5. Midlothian mine, at Midlothian. Operator, R. S. Burrows; product, 13,122 tons; thickness of coal, 4⅔ feet. Market, Richmond and Manchester, Va.

At present there are but two companies operating in the field—the Virginia Coke and Coal Company at Winterpock (Clover Hill) and a company at Gayton on the north side of the James. The latter company also controls the Grove shaft, which has not been reopened since the burning of the surface works a few years ago.

PROSPECTIVE DEVELOPMENT.

The present operators hold to the policy of reaching the central portion of the basin by means of existing slopes and shafts sunk on the eastern outcrop, and are thus following the coal without testing the ground in advance of their workings by means of the drill. While this policy obviates the expense of drilling and the initial cost of deep shafts in the middle of the basin, its continuance must leave for several years the actual occurrence of workable beds of coal in the central portion of the basin a matter of inference, with the prospect that the lengthening of existing slopes must ever increase the cost of bringing the output to the surface. None of the borings so far made at a distance from the margin have penetrated to the crystalline basement so as to reveal the number, thickness, or extent of the coal beds which may underlie the area.

DISTRIBUTION.

LOCATION OF MARKETS.

In the past a market has been found for the Richmond coals in Richmond and in the seaports along the North Atlantic coast. Prior to the introduction of the western coals a relatively large amount was used for gas making in Philadelphia, and within recent years the natural coke has sold in the Boston market at $3.50 a ton.

*Tenth Census U. S., Vol. XV, p. 927.

PRESENT ROUTES TO POINTS OF CONSUMPTION.

The coals from Gayton are moved by a private railroad to Lorraine, where connection is made with the James River division of the Chesapeake and Ohio, connecting with Richmond and West Point. The Grove shaft, near Midlothian, has a connection with the Southern Railway at Midlothian, allowing transportation to Richmond. The Farmville and Powhatan narrow-gage road crosses the southern part of the field, carrying the Winterpock coals to Chester, a connection on the Seaboard Air Line, from which distribution can be made to cities and towns along the edge of the Coastal Plain.

FARMVILLE AREA.

LOCATION AND BOUNDARIES.

This area lies in Buckingham, Cumberland, and Prince Edward counties, Virginia, about midway between the eastern and western Triassic belts. Farmville is a station on the Norfolk and Western Railroad and the terminus of the Farmville and Powhatan narrow-gage railroad. The area has a northeast-southwest extension of 20 miles and a maximum width of about 5 miles, with a surface of 60 square miles. The southern part of the area forms a small detached basin 6 miles south of Farmville, being separated from the main basin by nearly 2 miles of mica-slate, gneiss, granite, etc., exposed in the vicinity of King's tavern. The entire area is surrounded by the rocks of the Piedmont district. Granite occurs on the eastern border.

GEOLOGIC RELATIONS.

AGE OF THE STRATA.

The rocks are of Triassic age, and in general show a close correspondence with the section in the Richmond area on the east.

STRATIGRAPHY.

The details of the stratigraphic succession have not been definitely determined. W. B. Rogers gave the following list of strata crossed north of the Appomattox River going from Raine's tavern toward Kurdsville:

Strata crossed north of Appomattox River going from Raine's tavern toward Kurdsville.

1. Near the tavern the margin of the area appears, with soft gray sandstones, with vegetable impressions, and a thin seam of carbonaceous matter exposed on the farm of William S. Walton (1839).
2. Red and green shales and sandstones, hard and soft, for nearly 2 miles.

3. Yellowish and brown soft sandstones, and near Cook's mill a ledge of bluish slaty sandstone, containing a spiral univalve shell and rhombic fish scales.

4. Yellowish and reddish shales and sandstones.

5. On the western margin, an extremely coarse conglomerate, composed of fragments of the rocks of the Piedmont region.

STRUCTURE.

Our knowledge of the structure of the area is mainly due to a reconnaissance made by I. C. Russell in 1885.[a] According to this geologist, the strata are much disturbed, sometimes dipping to the west and sometimes to the east. At least four north-south faults affect the central portions of the area. On the eastern border, about 2 miles north of Farmville, a heavy marginal fault has been shown in mines. Here the coal-bearing beds abut against granite. In the small area on the south the prevailing dip is 20° W. No faults have here been detected and no folds are known.

THE COAL.

A number of thin seams of coal have been found. W. B. Rogers reported the existence of a seam of bituminous coal nearly 2 feet thick in the southern end of the southern basin. Several very thin seams of coal were also encountered in dark shales and brown sandstones in borings at Morton's mills and on the Bizarre estate (1839). Professor Rogers stated that the material of these seams is usually a friable mixture of carbonaceous and earthy matter, in some places assuming the appearance of a hard bluish-black mass of rather porous texture, resembling coke. Dikes occur in the area. In his official report, Rogers discouraged attempts at mining coal in this field. No important discoveries of coal have been reported since his time.[b]

DEVELOPMENT.

The field is practically undeveloped, and beyond the thin seams of unsatisfactory coal found about the margin nothing is known of the basin at a depth.

The field is crossed by the Norfolk and Western Railway, connecting on the west with Lynchburg and on the east with Petersburg, City Point, and Norfolk.

DEEP RIVER AREA.

There are two coal-bearing Triassic areas in North Carolina shown on the map (Pl. V). These are the eastern or Deep River area, including the Wadesboro detached area, and the western or Dan River

[a] Bull. U. S. Geol. Survey No. 86, 1887, pp. 88-89.

[b] Reprint of Annual Reports and other papers on the Geology of the Virginias, New York, 1884, pp. 327-328.

area. The principal productive coal beds are found in the Deep River district, in Chatham and Moore counties. The Dan River region is regarded as of little promise. The relations of the two fields are shown in the diagram (fig. 3).

LOCATION AND EXTENT.

The Deep River area forms a northeast-southwest belt in the central portion of the State, extending northward nearly to the Virginia line and southward into South Carolina. The productive area, about 30 miles long, lies wholly within North Carolina.

The rocks of the area appear on the north about 6 miles southeast of Oxford, in Granville County, whence they extend southwestward to the Cape Fear River. South of this stream they continue as a somewhat tortuous belt in the Deep River region to within about 10 miles of the Yadkin River. On the Yadkin, and a few miles west of the southern end of the Deep River area proper, the Wadesboro area begins and extends in the same general direction 6 or

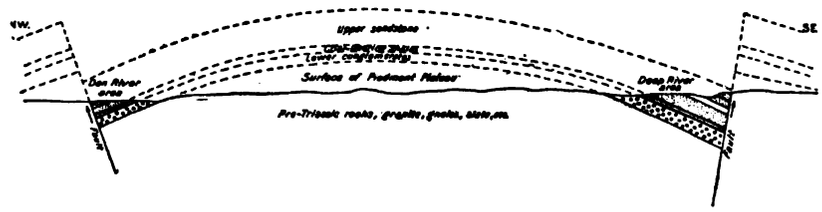


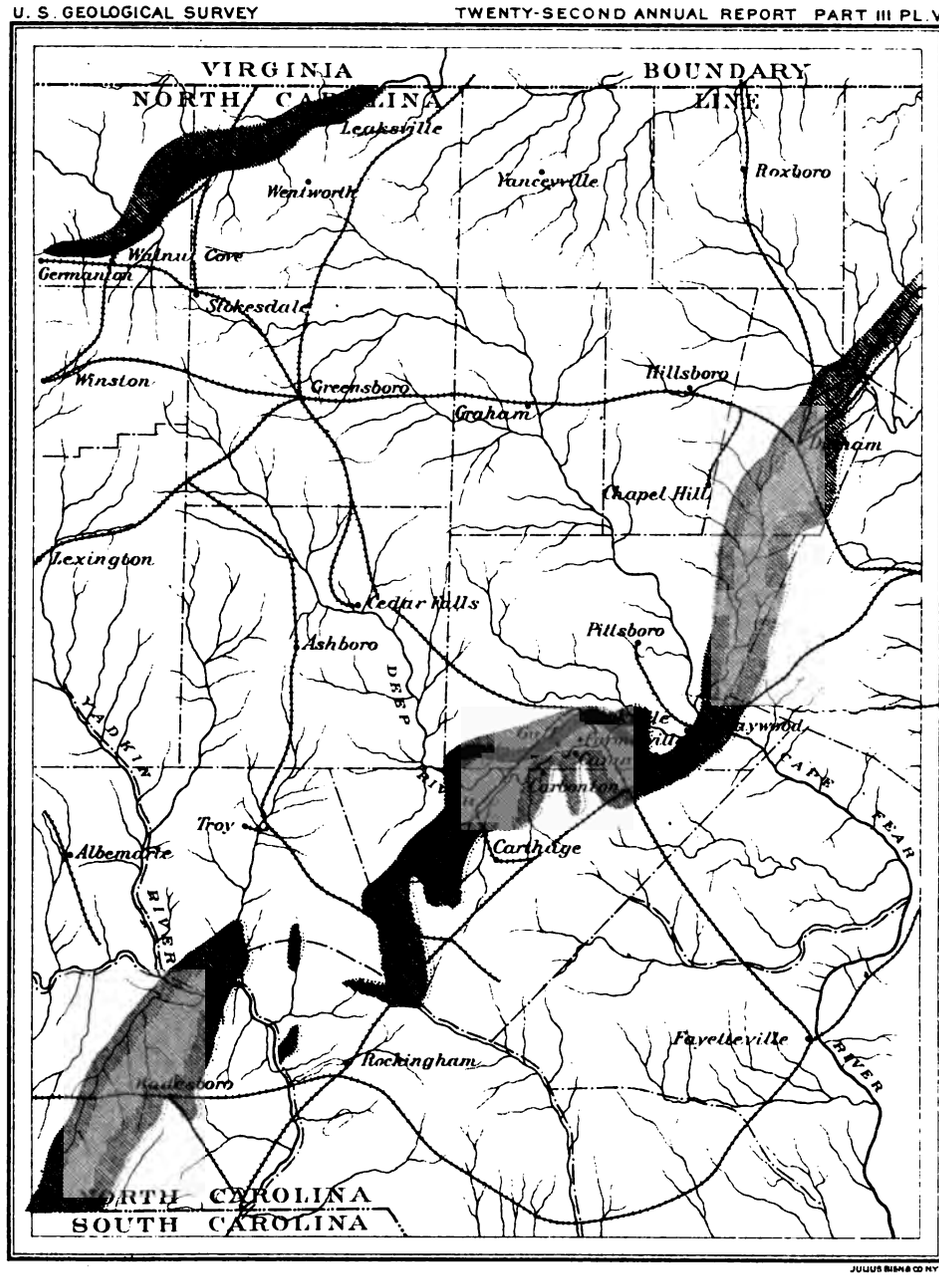
FIG. 3.—Section showing probable relation of Dan River and Deep River Triassic areas. The eastward dip of the beds in the Deep River area is generalized; westward dips also occur.

7 miles into South Carolina, in the vicinity of Carew. The total length of the whole belt is over 60 miles. Its average width is about 12 miles, its greatest width being as much as 18 miles. The total area has been estimated at between 250 and 300 square miles. Between the larger northern and southern areas are small detached basins of Triassic rocks not known to be coal bearing.

GEOLOGIC RELATIONS.

STRUCTURE.

The area displays the prevailing structure of the Triassic belts along the Atlantic coast, the basal strata of one side of the belt reposing on the ancient crystalline rocks of the Piedmont district, the opposite margin bearing evidence of being thrown down by faults. The usual dip of the strata in this area is southeast, the angle being about 15°. According to Russell, the notches in the boundaries probably indicate faults, several of which are exposed in railroad cuts within the area. Evidence of faulting is also seen in the narrow strip of Triassic strata near the western border, in the vicinity of Lockville.



DEEP AND DAN RIVER COAL BASINS

NORTH CAROLINA

After Kerr

Scale

0 5 10 20 30 40 MILES

LEGEND

Triassic areas

Productive areas

The coal-bearing beds show a distinct curvature where crossed by the Deep River northeast of Cumnocks. In other respects the structure, as revealed in workings, appears to be more regular than that of the Richmond area in Virginia.

STRATIGRAPHY.

The strata, numbered from the bottom upward, are given as follows in the State reports:

Strata in Deep River area, North Carolina.

	Feet.
3. Sandstones, grits, and upper conglomerates	3,000
2. Black shales, with coal beds	500 to 600
1. Conglomerates and sandstones	1,500

THE COAL.

NUMBER, THICKNESS, AND EXTENT OF THE BEDS.

As in the Richmond and other Triassic areas, the coal beds are near the base of the Newark formation. The coal-bearing strata have been well exposed in the old shaft at Egypt, now Cumnocks. Fig. 4 is reproduced from the report on this mine made by Captain Wilkes in 1858.

FIG. 4.—Section of strata exposed in the old Egypt shaft. (After Wilkes, 1858.)

Five coal seams have been proved at the Farmville and Hornesville mines. Their thicknesses, beginning with the highest, are given as 3, 1, 3, 2, and 4 feet. At the Cumnock mine there are two beds, one 4 and the other 2 feet in thickness, separated by 2 feet of blackband iron ore. At Taylor's mines three seams were reported, with a thickness of from 18 to 30 inches, 2.5 to 3 feet, and 4 feet, respectively. At Wilcox's the Murchison seam is described as being 8 or 9 feet thick, but containing shale. The coal outcrop has been traced for 30 or 40 miles in the central part of the State southwestward from the vicinity of the Cape Fear River.

The accompanying sketch map and section (figs. 5 and 6), by Kerr, show the position of the outcrop and details of the coal section near Gulf.

Chance* found at Farmville, N. C., five beds of coal in the following section, which measured 40 to 50 feet from the roof of the uppermost coal bed to the floor of the lowest.

*Trans. Am. Inst. Min. Eng., Vol. XIII, pp. 517–520.

Section of coal beds at Farmville, N. C.

Slate roof.
Coal, good ..... 3 feet to 3 feet 2 inches.
Blackband and slate ..... 1 foot 8 inches to 3 feet.
Coal, poor, shaly ..... 1 foot to 2 feet.
Pure clay floor.

CHARACTER AND CHEMICAL COMPOSITION OF THE COAL.

The coal is normally bituminous, but owing to the coking action of intrusive rocks passes locally into anthracite and even a graphitic vari-

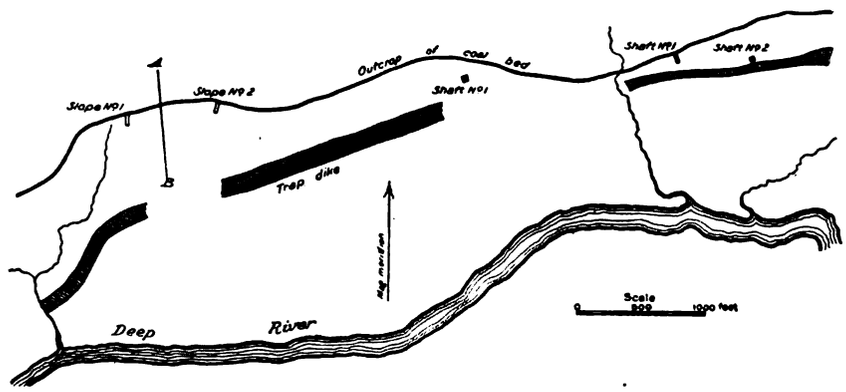


FIG. 5.—Sketch map showing outcrop of coal at Gulf, Chatham County, N. C. (From W. C. Kerr Report on the Geological Survey of North Carolina, Vol. I, 1875, p. 144.)

[illegible] On the other hand, semibituminous varieties have been encountered. The bituminous coal is rated as excellent. It burns freely, cakes, or partly fuses and agglutinates, forming a partly impervious hollow cake in which combustion goes on for a long time. It may be ignited in the blaze of a candle, and burns with a bright flame. It makes excellent coke and illuminating gas, and is free from sulphur (MacFarland). The coal leaves very little purplish-gray ash.

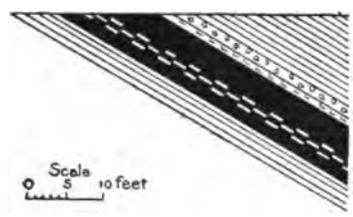


FIG. 6.—Section of coal at Gulf, Chatham County, N. C. (After Kerr.)

Natural coke or carbonite is reported as occurring in the old Wilcox mine, where it was known as "dry coal." Its outcrop corresponds in thickness with the upper seam, which farther north is unaltered.[a]

Above the coal Wilkes describes the shales as very inflammable and burning with a white flame. An analysis showed 20 per cent of fixed carbon and 30 per cent of volatile matter.[b]

[a] C. Wilkes, Report, p. 9. [b] Wilkes, loc. cit.

Analyses of coals from Deep River area, North Carolina.

Location.	Analyst.	Fixed carbon.	Volatile matter.	Ash.	Sulphur.	Water.	Fuel ratio.
Farmville:							
Lower seam—							
Sample I	Emmons[a]	50.70	30.91	18.32	.....	.....	1.64
Sample II	.....do	64.70	28.47	6.83	.....	.....	2.23
Sample III	.....do	63.90	30.85	5.25	.....	.....	2.06
Sample IV	.....do	64.40	31.30	4.30	.....	.....	2.06
Upper bed—							
Sample I	Battle[b]	58.30	29.56	7.46	2.89	.....	1.97
Sample II	.....do	58.47	30.54	6.85	2.19	.....	1.91
Lower seam—							
Sample III	.....do	60.59	28.66	5.35	3.69	1.71	2.11
Sample IV	.....do	51.24	28.71	14.51	4.18	1.36	1.79
Sample V	.....do	52.56	28.88	12.69	3.72	2.15	1.81
Sample VI	.....do	50.04	26.87	14.69	7.08	1.32	1.86
Egypt:							
Deep pit	Dr. Jackson[c]	63.60	34.80	1.60	.....	.....	1.82
Do	G. C. Shaefer[c]	60.70	32.70	5.30	1.30	.....	1.82
Do	J. H. Cremer[c]	64.19	27.85	4.24	1.77	1.95	2.35
Do	Endeman[c]	63.32	31.42	4.12	1.99	1.14	2.01
Gulf, North Carolina:							
Upper bed, specific gravity 1.295.	F. W. Clarke[d]	72.44	24.48	3.08	.99	.....	2.96
Middle bed, specific gravity 1.339.	.....do	67.86	24.22	7.92	1.42	.....	2.80
Lower bed, specific gravity 1.359.	.....do	66.37	23.94	9.69	3.33	.....	2.77

[a] Geological Report, Midland counties of North Carolina, 1856, pp. 247, 248.
[b] Chance, Trans. Am. Inst. Min. Eng., Vol. XIII, pp. 517–520.
[c] Collected by Russell; Bull. U. S. Geol. Survey No. 42, 1887, p. 146.
[d] State Board of Agriculture, North Carolina and its Resources, 1896, p. 104.

In Specimens I and II of Dr. Battle's analyses Chance describes the coal as friable, breaking down readily into a fine slack, and as coking quickly and thoroughly. Specimens III, IV, and V pertain to a coal which is hard, having a columnar structure and bright fracture, with very little pyrites; burning with a strong flame and coking slowly, not commencing to coke until highly heated.

In the analyses by Dr. Clarke the coke is described as good, the ash gray. The coals gained weight on drying at 115°.

DEVELOPMENT.

HISTORY.

Coal was discovered in this area in the latter part of the eighteenth century. The present productive field was exploited by shafts in the middle of the nineteenth century, but systematic mining may be said only to have begun with the reopening of the Egypt shaft at Cumnocks in 1889.

In the Mining Directory of the Tenth Census,[a] for 1880, the following mines were named in the Deep River area:

1. Gulf mine; operator, E. L. Houghton; product, 200 tons. Thickness of coal, 6½ feet. Market, Raleigh, Charlotte, Fayetteville, and Lawrenceburg.
2. Egypt mine. Not operated. Thickness of coal, 4½ feet. Market, Raleigh, Fayetteville, Portsmouth, and Wilmington.

According to the report of the State board of agriculture, the Cumnock mines (the old Egypt coal mine) were the only operating collieries in North Carolina in 1896. Operated in a desultory and primitive way before 1888, they were then enlarged and refitted under a new management. The colliery is operated by two perpendicular shafts; one, for ventilation only, measuring 8 by 10 feet, taps the vein in the rise workings at a depth of 220 feet; and the main working shaft is 8 by 12 feet and 464 feet deep. The plant in 1898 had a capacity of 1,000 tons per day.

The Cumnock Company owns 4,300 acres. The workable veins aggregate 6 feet in thickness, lying in two benches of 4 and 2 feet, separated by 2 feet of blackband iron ore. With a specific gravity of 1.31 for the upper seam and 1.43 for the lower, it is estimated that 11,000 tons to the acre, or 47,300,000 tons, exist within the holding of this company alone.

The Greensboro Gas Company reports that a quantity of this coal made 9,700 cubic feet of gas, 18.5 candlepower, and 49 bushels of good, clean, hard coke. It has proved successful as a locomotive coal. It was shipped as a blacksmith coal to local points on the Norfolk and Western Railroad. It is an excellent grate coal.[b]

At present the Chatham Coal and Iron Company, C. F. Pendleton, superintendent, is operating collieries at Cumnock, and the North Carolina Coal and Coke Company, George F. Cant, superintendent, is engaged in mining at Gulf.[c]

STATISTICS OF MINES AND PRODUCTION.

The use of coal from this field began in an irregular way early in the last century. Between 1860 and 1865 it is estimated that about 60,000 tons were taken out of the mines then in existence, and about 350 tons were mined in 1880. The systematic development of the old Egypt shaft, now the Cumnock property, began in 1889, and the following statistics, published in Mr. E. W. Parker's report for 1899, give the production to the close of that year. A fire in the mine curtailed the output in 1898.

[a] Tenth Census United States, Vol. XV, p. 899.
[b] State Board of Agriculture, North Carolina and its Resources, Winston, 1896, pp. 104-105.
[c] Letter of Prof. Collier Cobb, February 28, 1901.

Coal product of North Carolina since 1889.[a]

Year.	Short tons.				Total value.	Average price per ton.	Average number of days active.	Average number of employees.
	Loaded at mines for shipment.	Sold to local trade and used by employees.	Used at mines for steam and heat.	Total product.				
1889				192	$451			
1890				10,262	17,864			
1891	18,780	600	975	20,335	39,635	$1.93	254	80
1892	6,679			6,679	9,599	1.44	160	90
1893	15,000		2,000	17,000	25,500	1.50	80	70
1894	13,500	1,000	2,400	16,900	29,675	1.76	145	95
1895	23,400	600	900	24,900	41,350	1.66	226	61
1896	5,356	295	2,162	7,813	11,720	1.50	220	18
1897	21,280			21,280	27,000	1.34	215	51
1898	9,852	304	1,339	11,495	14,368	1.25		
1899	24,126	486	2,284	26,896	34,965	1.30	210	70

DISTRIBUTION.

The coal at Cumnocks is shipped directly by the Cape Fear and Yadkin Valley Railroad, connecting with the Seaboard Air Line at Colon by means of the Raleigh and Western Railroad, which in turn offers a connection with the Southern Railway in Randolph County.

It has found a good market along the Norfolk and Western Railroad as a blacksmith coal.

DAN RIVER AREA.

LOCATION AND EXTENT.

This area is the southern part of a belt which begins about 10 miles north of the Virginia line and extends southwestward into North Carolina through Rockingham and Stokes counties as far as Germantown, a distance of about 30 miles. It is separated by a few miles of Piedmont rocks from a nonproductive northern area which extends as far north as Appomattox County in Virginia. The breadth of the Dan River area is said to be not less than 4 and not more than 7 miles. It is surrounded by gneisses believed to be of Archean age.

[a] E. W. Parker, The production of coal in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, Pt. VI, p. 158.

GEOLOGIC RELATIONS.

The age of the beds is the same as that of the previously described areas, Upper Triassic.

STRATIGRAPHY.

The stratigraphy of the area is similar to that of the Deep River area, conglomerates at the base being overlain by the coal-bearing shales, which are succeeded by a thick sandstone series and fine conglomerate toward the top. Little available knowledge exists concerning the details of the bedding.

STRUCTURE.

The structure of the area is apparently that of a westward-dipping fault basin, with the downthrow and a fault or faults on the western margin. The rocks dip northwest. The angle of dip varies from 15° to 40°, and is usually greater than 20°.[a]

The strata are known to be intersected by a few trap dikes, which acted as coke makers where they cut the coal.

THE COAL.

The coal lies near the base between beds of shale. The outcrop of the coal-bearing series is mapped by Kerr from Germantown to near Leaksville. The main coal seam is said to be about 3 feet thick, varying from 2 to 7 feet. At Stokesburg there are three seams, the uppermost about 3 feet thick. One of the lower seams is reported to be much thicker. Near Leaksville, a slope was driven about 60 feet on the coal seam, which there is about 3 feet thick, and has a dip of 34°. Coal was mined here during the civil war. At Germantown, two beds of coal are reported, each 18 inches thick, separated by 1 foot of "slate."

Professor Holmes,[b] of the North Carolina geological survey, in 1891 drilled two holes near Walnut Cove, Stokes County, one going down 1,112 feet without encountering valuable beds of coal, thus preventing, it is claimed, many profitless mining operations. This geologist is of the opinion that the indications are more favorable near the southwest end of the basin, between Walnut Cove and Germantown.

The coal at Leaksville is classed as semibituminous or dry coal. It is brittle and crumbles readily in the air, but cokes easily, and is claimed to be a good gas coal.[c]

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[a] The Coal Regions of America, by James MacFarland, 1873, p. 527, citing E. Emmons, Report, 1856, p. 255.

[b] First Biennial Report N. C. Geol. Survey, Raleigh, 1893, pp. 16–17.

[c] North Carolina and its Resources, 1896, p. 103.

ANALYSES.

The following analyses have been made of coals from this field:

Analyses of coal from Dan River area.

	I.[a]	II.[a]	III.[b]
Fixed carbon	75.96	76.56	55.47
Volatile matter	11.44	13.56	17.99
Ash	12.00	12.00	26.16
Sulphur			5.56
Water			.38

[a] Analyses by Dr. Genth, about 1871, from coal near Stokesburg.

[b] Coal from Walnut Cove, Stokes County; analysis by J. E. Whitfield, in Bull. U. S. Geol. Survey No. 42, 1887, p. 146.

DEVELOPMENT.

No coal has been shipped from this area in many years, and the probabilities are that the seams of merchantable coal are too thin to repay working under the existing conditions of mining coal in other fields.

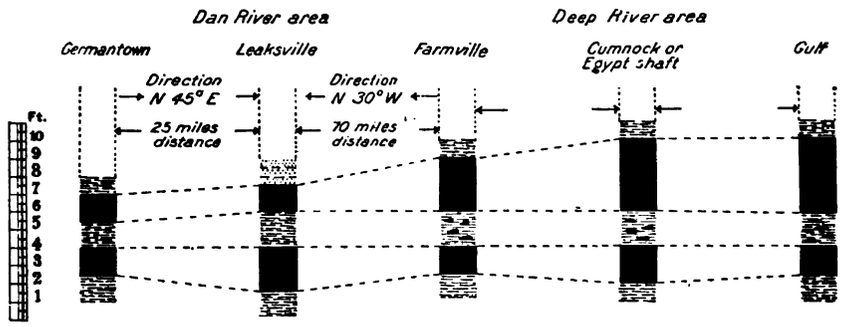

FIG. 7.—Columnar sections of coal beds in the Dan River and Deep River areas. Dotted lines indicate supposed original continuity of strata. Dip corrected.

The explorations carried on by the State board of agriculture adjacent to the Dan River are described in Mineral Resources of the United States for 1887, pp. 280–281. It should be noted that the promising conditions there cited from the report of the State engineer were later regarded as fallacious by the State geologist, and the area is now held to be practically worthless.

The accompanying figure (fig. 7) of the coal beds in North Carolina is intended merely to show the supposed correlation of the strata in the Deep River and Dan River areas. The dotted lines indicate supposed continuity of original bedding. The dip of the strata has been corrected for the purpose of comparison

POSSIBLE EXISTENCE OF TRIASSIC COAL BASINS BENEATH THE COASTAL PLAIN.

The fact that a boring through the Coastal Plain near Florence, S. C.,[a] penetrated a patch of the Triassic in that region makes it reasonable to expect that other Triassic areas lie east of the Richmond and Deep River areas outside of the fall line and under a thick cover of newer Mesozoic sands and clays. Even if such areas proved to be coal bearing it is hardly possible that this source of supply will be exploited until the existing fields having a surface exposure have been exhausted.

SUMMARY OF PRODUCTION.

The following table shows the production of the Atlantic coast Triassic coal fields for the twenty years from 1880 to 1900:

Development of the Atlantic coast Triassic coal field by decennial periods.

Locality.	1880.			1890.		
	Production.	Value.	Average price per ton.	Production.	Value.	Average price per ton.
Chesterfield and Henrico counties of Virginia, and North Carolina	*Tons.* 43,429	$100,202	$2.30	*Tons.* 45,262	$77,864	$1.72

Locality.	Increase of 1890 over 1880.				1900.		
	Production.	Per cent.	Value.	Per cent.	Production.	Value.	Average price per ton.
Chesterfield and Henrico counties of Virginia, and North Carolina	*Tons.* 1,833	4	[b]$22,338	22	*Tons.* 57,912	$103,777	$1.79

Locality.	Increase of 1900 over 1890.			
	Production.	Per cent.	Value.	Per cent.
Chesterfield and Henrico counties of Virginia, and North Carolina	*Tons.* 12,650	27	$25,913	33

[a] N. H. Darton, Bull. U. S. Geol. Survey No. 138, p. 218.

[b] Decrease.

LITERATURE.

Russell, I. C. Correlation papers—The Newark system: Bull. U. S. Geol. Survey No. 85, Washington, 1892.

This work contains an analytic list of all books and papers published in relation to the Newark areas up to the date of issue. The following papers relate to the coal-bearing areas.

Rogers, W. B. Reprint of annual reports and other papers on the geology of the Virginias, New York, D. Appleton & Co., 1884.

Shaler, N. S., and Woodworth, J. B. Geology of the Richmond Basin, Virginia: Nineteenth Ann. Rept. U. S. Geol. Survey, Pt. II, 1899, pp. 385–519.

Emmons, Ebenezer. Report of Professor Emmons on his geological survey of North Carolina, Raleigh, 1852, pp. 113–159.

Wilkes, C. Report on examination of Deep River coal field: Thirty-fifth Congress, second session, Doc. 26, vol. 7, 1858–59, pp. 1–29, pls. 1, 2, maps.

Kerr, W. C. Report of the geological survey of North Carolina, Vol. 1, Raleigh, 1875, pp. 141–147, 293–295.